Prime Meridian

(38) March 31, 2015

Above: A spacecraft descends through the cloud deck onto the surface of the one habitable world of which we presently know. This picture may be destined to become much-reproduced. Taken by it Bill Ingalls (NASA), it shows a Soyuz TMA-14M spacecraft returning home from the International Space Station, which orbits around 400 km above Earth's surface. Aboard were Barry Wilmore of NASA (mission commander of International Space Station Expedition 42), Alexander Samokutyaev and Elena Serova (Russian Federal Space Agency; Roscosmos). The craft landed in Kazakhstan SE of the town of Zhezkazgan, bringing to a close 167 days aboard the ISS.

Climate change is speeding up.

Policy-makers take note: over the last few weeks, yet another crop of research papers have been published, which suggest, disturbingly, that our global environment is changing much faster than expected.

2050 and 2100 are no longer science fiction dates, set in a future too distant to directly affect anyone alive today. Without assuming any major medical advances that could slow or reverse the ageing process (and such developments may well occur), a good proportion of today's teenagers should expect to see the late 21st Century and children playing in the kindergarten today should see the early 22nd Century. What we do today will decide the kind of world they inherit from us. Adaptation to looming changes threatens to be immensely expensive and would take many years of intensive planning and preparation. Unfortunately, our impact on our planet is not only growing, but not necessarily growing in a predictable way. At the same time, predictions about how Earth systems will respond to the multiple pressures that we are exerting on them will change as scientific knowledge moves forwards.

In order to fulfil their responsibility to safeguard human communities, policy-makers are going to have to hit a moving target.

The rate of global warming is accelerating.

A newly published study from researchers at the Pacific Northwest National Laboratory, Maryland, USA has analysed climate change in 40 year chunks and concluded that the overall trend has been for climate change to gather speed. During the last thousand years, the rate at which temperature has changed has been mostly less than 1°C per decade, but by 2020, it could have increased to 0.25°C per decade. In the Arctic, the rate of increase is greater than anywhere else on the planet and by around 2030, it could be nearly 0.6°C per decade.

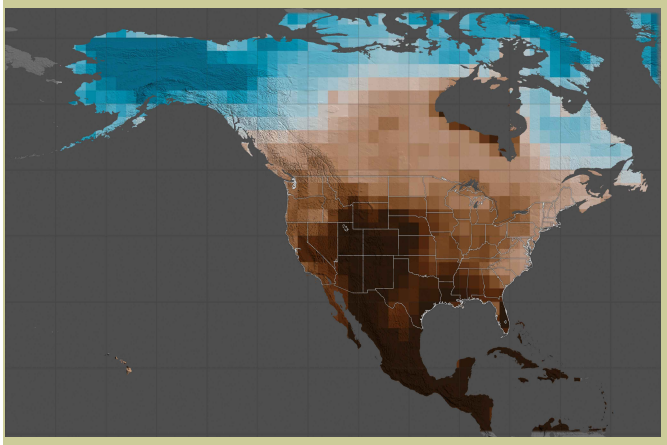
The authors noted that their results did not include the recent decrease in the rate of warming, but considered that due to natural variability in climate "*such a temporary slow-down is neither unusual nor unexpected*" Also: "*The accelerated rates of change noted here mean that impacts related to rates of change will intensify over the coming decades. Research on such impacts, and also on potential adaptation measures, is urgently needed to guide adaptation.*" Reference: Smith, S. J. (2015). *Nature Climate Change*. Advance publication online. ww.nature.com/natureclimatechange.

Recent jump in the rate of sea level rise was greater than thought.

A number of previous studies have indicated that global mean sea level (GMSL) rose at an average rate of 1.6 to 1.9 mm per year during the 20th Century (Wenzel & Schroeter, 2010).

However, estimates of the rate at which ice sheets were melting on land, the storage of water on land, and the expansion of the ocean as it warms fell short of explaining this sea level rise.

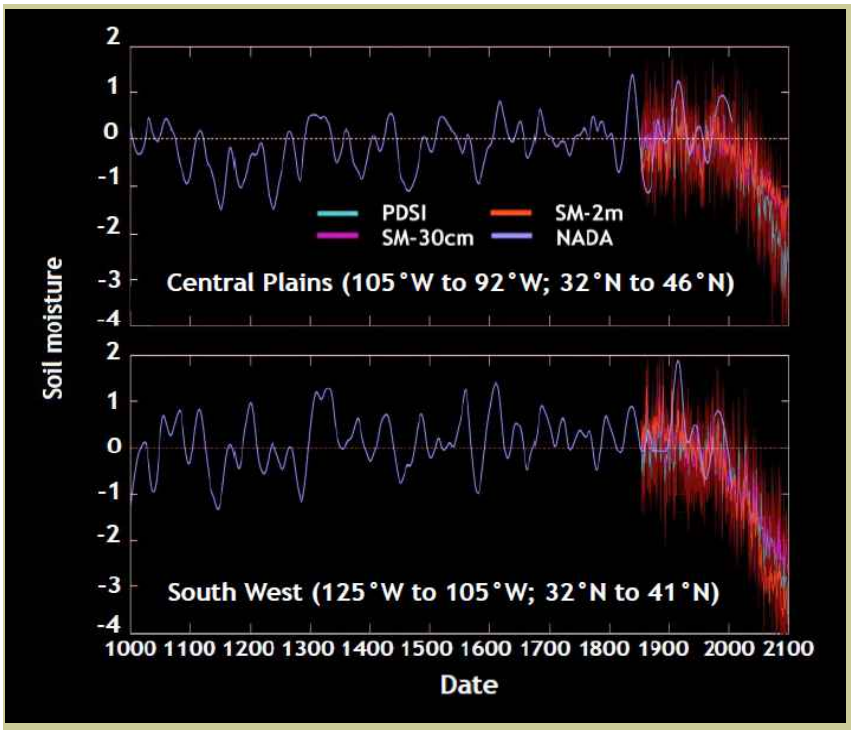
Now, a new investigation led by Carling C. Hay of Harvard University, Massachusetts and Rutgers University, New Jersey, USA (Hay *et al.*, 2015) appears to have closed the gap with a new estimate of 1.2 ± 0.2 mm per year for the period 1901 to 1990 (90% confidence interval). The study also confirmed that the sea level rise over the interval 1993 to 2010 was much faster, 3.0 ± 0.7 mm per year. This means that the jump from typical 20th C rates to the present rate was greater than had been thought. It was over 240%. Above: The sea shore at Hastings, England, Aug. 30, 2010. References: Hay, C. C. *et al.* (2015). *Nature* 517: 481-484. Wenzel, M. & Schroeter, J. (2010). *J. Geophys. Res.* 115: C08013.



Shift in climate threatens the South West USA and the Central Plains with "*unprecedented*" droughts.

The future for the USA's South West and the Great Plains holds the prospect of droughts far more intense than any that have occurred during historical times according to new study led by Benjamin Cook of the NASA Goddard Institute for Space Studies (New York, USA). It put together estimates of a millennium of rainfall and temperature from tree rings and predictions for future climate from 17 models. It was the most rigorous treatment attempted for the region.

The study looked at the implications of both high (climate model RCP 8.5) and moderate (RCP 4.5) greenhouse gas emissions. In both cases, between the middle and end of the 21st Century, droughts, deepened by global warming, might persist for decades, perhaps even half a century. The risk of drought will exceed that of the driest centuries of the Medieval Climate Anomaly (1100 to 1300 AD). Above left: Brown shows areas drier than 20th C average and blue shows areas that become wetter.



A plunge drought.

The graphs at left are re-drawn after Figure 1 of Cook and co-workers (2015). It shows the past history of droughts from the North American Drought Atlas and the estimated future of water availability expected from climate models.

NOTE: PDSI = Palmer Drought Severity Index; SM-2m = Soil Moisture at 2 to 3 m depth; SM-30cm = Soil Moisture at 30 cm depth; NADA = North American Drought Atlas; the red area is the interquartile range for model PDSI. The Palmer Drought Severity Index is a widely used measure of the availability of soil moisture in any locality.

The PDSI is calculated from the amount of water being supplied in rainfall and the amount that is lost through evaporation and also through plants in the process of transpiration (where by water rises through the roots and is lost through the leaves). Scientists often lump the two together as "*evapotranspiration*."

Mediaeval droughts in the region were worse than recent droughts and future droughts will be worse even than those of Mediaeval times.

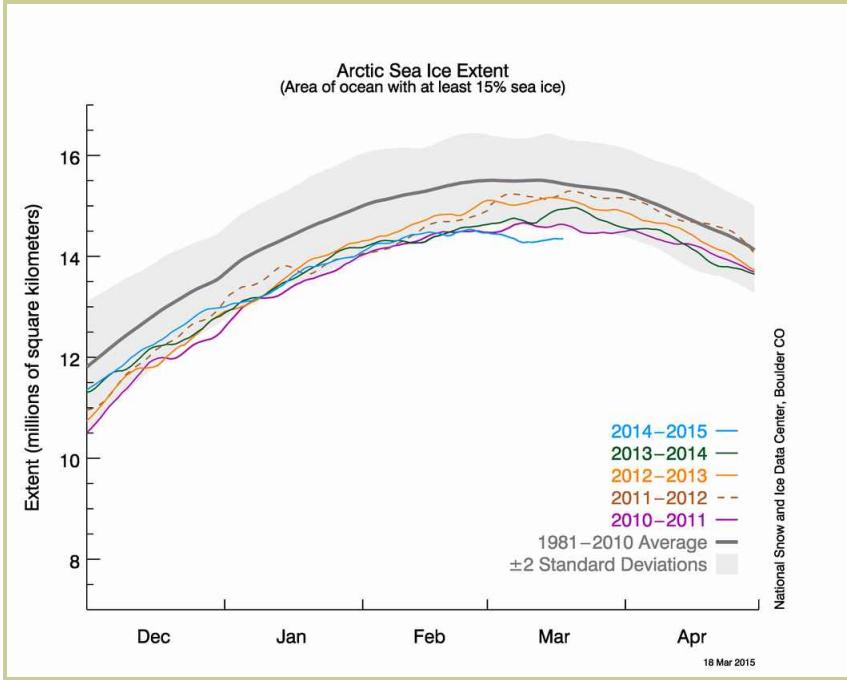
Looking back into the past, Benjamin Cook and his colleagues (2015) discussed how: "*Millennial-length hydroclimate reconstructions over Western North America* [Cook *et al*. 2007; 2010 Meko *et al*. Woodhouse *et al*. 2010] *feature notable periods of extensive and persistent Medieval-era droughts. Such "megadrought" events exceeded the duration of any drought observed during the historical record and had profound impacts on regional societies and ecosystems*." Looking ahead and combining climate models, it appeared that the coming droughts could be significantly worse than those of Mediaeval times, with the intensity of the most extreme droughts increasing from the present onwards. A "*megadrought*" would involve at least 35 years of drought.

The team commented: "*Our results point to a remarkably drier future that falls far outside the contemporary experience of natural and human systems in Western North America, conditions that may present a substantial challenge to adaptation. Human populations in this region, and their associated water resources demands, have been increasing rapidly in recent decades, and these trends are expected to continue for years to come* [MacDonald, 2010]. *Future droughts will occur in a significantly warmer world with higher temperatures than recent historical events, conditions that are likely to be a major added stress on both natural ecosystems* [Williams *et al*., 2013] *and agriculture* [Lobell *et al*., 2014]." They pointed out that there has been a massive dependence on tapping groundwater [Long *et al*., 2013; Scanlon e*t al*., 2012] and that this has enabled people to reduce the damaging effects of drought. The problem here is that these underground supplies of water are limited and are being used up. "*In some cases, these losses have even exceeded the capacity of Lake Mead and Lake Powell, the two major surface reservoirs in the region* [Castle *et al*., 2014; Famiglietti *et al*., 2011]."

The economic implications for the United States of America are profound. The present threat of a megadrought is 12 %, increasing to 60% if greenhouse gas emissions level off by 2050 and 80% if they continue to rise at present rates. There exist no contingency plans to deal with such events and it is a matter of urgency that the policy-makers address the problem.

References: Castle, S. L. *et al*. (2014). *Geophys. Res. Lett.* 41: 5904-5911. **Cook, B. I. *et al*. (2015).** *Sci. Adv.* 1: e1400082. **Cook, E. R. *et al*. (2007).** *Earth Sci. Rev.* 81: 93-134. **Cook, E. R. *et al*. (2010).** *J. Quat. Sci*. 25: 48-61. **Famiglietti, J. S. *et al*. (2011).** ***Geophys. Res. Lett*. 38: L03403. Lobell, D. B. (2014).** *Science* 344: 516-519. **Long, D. *et al*. (2013).** *Geophys. Res. Lett*. 40: 3395-3401. **MacDonald, G. M. (2010).** *Proc. Natl. Acad. Sci. U.S.A.* 107: 21256-21262. **Meko, D. M. *et al*. (2007).** *Geophys. Res. Lett*. 34: 10705. **Scanlon, B. R. (2012).** *Proc. Natl. Acad. Sci. U.S.A.* 109: 9320-9325. **Williams, A. P. *et al*. (2013).** *Nat. Clim. Change* 3: 292-297. **Woodhouse, C. A. *et al*. (2010).** *Proc. Natl. Acad. Sci. U.S.A.* 107, 21283-21288.

Lowest Arctic sea ice maximum in the satellite record.



Every year, around the spring equinox (March 20 this year), at the end of the long Arctic night, the floating sea ice reaches its maximum annual extent. For 1981-2010, the average date of the maximum was March 12. This year, however, it took place on Feb. 25, when the extent of the ice was 14.54 million km^2. On March 20, the Sun rose at the North Pole and as temperatures in the Arctic rise, the melt season will be underway, with the sea ice shrinking away until around the time of the autumn equinox.

The extent of the sea ice is defined as the area with over 15% ice cover.

There were higher than normal temperatures in the Okhotsk and Bering Seas and the only areas in which sea ice extent was not below average were the Labrador Sea and Davis Strait. A melt season beginning with a record low does not bode well for the amount of sea ice that will remain at the end of this coming summer. There has been a great deal of debate among climate scientists about whether the loss of Arctic sea ice, which would allow more energy from the Sun to be absorbed by, and so warm, the Arctic Ocean, could take us through a "*tipping point*" at which climate would jump abruptly into a different state (see discussion in Prime Meridian 26, May 31, 2014).

WWF fears oil exploitation could disrupt 40% of Congo's Virunga National Park.

The 7,800 km^2 Virunga National Park in the Democratic Republic of the Congo was established in 1925 and was recognised as a UNESCO World Heritage Site in 1979. Its spectacular scenery includes the Nyiragongo volcano, with its Africa's oldest national park, it is also hosts the greatest biodiversity. Its fauna includes the mountain gorilla (*Gorilla beringei beringei*), which is one of our rarest relatives. Image: LuAnne Cadd (2011) CC BY-SA 3.0.

The history of the Park has been chequered. It has been occupied by Rwandan refugees and insurgents. Poachers seize young gorillas for sale, killing family members who attempt to protect them. Numerous park rangers have been killed and almost a year ago, the Park's Director, Emmanuel de Mérode, was shot in the stomach and legs by an unidentified attacker. Intense economic pressures to develop hydrocarbon resources remain unabated around the world, despite commitments made at international climate conferences to major cuts in carbon emissions. Virunga National Park has now been targeted for oil exploration, which is attractive to the government because of the undoubted economic benefits. UK-based Soco International had been given oil exploration rights in large areas of the Park, but met with intense opposition from the World Wildlife Fund/World Nature Foundation, which recently stated: "*UK oil company Soco has committed to end its oil exploration operations in Virunga. Whilst we have received several assurances that the company have dismantled their operations, we continue to monitor the situation in the park. But for Virunga to be safe in the long-term we need the DRC government to cancel all oil exploration permits (as requested by UNESCO) and for sustainable development to start.* "

Seasons in South East England

January, 2015

Above: A hedgerow, mostly bare except for clinging ivy, disappears into the fog on January 4, 2015. Near West Kingsdown, Kent, England.

Warmer, wetter and sunnier than normal, but not escaping frosts and fogs.

Always a rather gloomy and chilly month for the Northern mid-latitudes, January 2015 was, even so, rather milder than normal. Look closely and one could discover signs of the coming spring.

The month was dived into a relatively mild first half and a colder second half. According to the UK Met Office, for the UK as a whole, the mean temperature for the month of January was 3.7ºC, which was 0.1ºC above the 1918-2010 mean. The mean hours of sunshine were 59.6, which was 126% the norm. There were 53.3 mm of rainfall (126% of the norm).

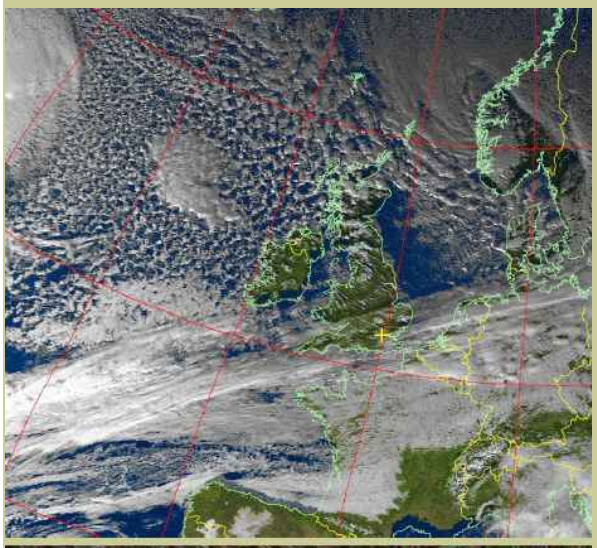
England saw its 4th sunniest January since 1929. According to the Met Office, "*The month began with mild conditions, and the regular passage of frontal systems bringing rain and showers, especially during the 7th to 14th with strong winds at times. It turned colder around the middle of the month, and the second half was rather less unsettled and much colder, with some low temperatures and sharp frosts at times; precipitation often fell as snow over higher ground*."

Westerly weather arrived with a series of depressions that swept in from the Atlantic. Notably deep lows crossed the UK between Jan. 9 to 15, bringing intense storms to Scotland. The South East escaped this extreme weather.

Left. A good-natured crowd gathered on a cold at New Year's night on Upper Telegraph Hill in South London, to glimpse the distant firework display beside the Thames that marked the beginning of 2015. The air was chill and it was a pleasure to return indoors. On Jan. 4, fog enshrouded South London's Crystal Palace TV mast and woods near West Kingsdown, Kent.

Above: The late afternoon Sun catches a bare hedgerow near West Kingsdown, Kent (Jan. 10, 2015).

Looking at the weather data for Heathrow (Greater London), the rainiest and warmest days in January occurred during the first half of the month. Jan. 3 saw 11 mm of rain and Jan. 8, 12 mm. On Jan. 12, there were 7 mm and there were 6 mm on Jan. 15. Meanwhile the highest temperatures achieved were around 14°C on Jan. 9 and 10. Jan. 9 saw the UK's warmest temperature (16.5°C) at Exeter Airport, Devon, SW England. The only time during the first half of the month when the minimum temperature at Heathrow fell below freezing was on Jan. 4, when it was less than -1°C.



Left: A view of the weather conditions over the UK on Jan. 10, 2015 taken at 13:36 GMT by the NOAA-19 satellite. Courtesy Geoff Hamilton.

Lesser celandine (*Ranunculus ficaria*) primroses (*Primula*) have already flowered in a gap between a tomb and the wall of St. Peter's and Paul's Church, Ash, Kent. Taken by flash (Jan. 10).

Below: This picture of the Sun through bare branches sums up this month of long nights. It was taken in the late afternoon of Jan.10, 2015. At this time of year, at around the latitude of Ash, Kent (51.28°), the Sun remains low in the sky, even at noon. The Earth's axial tilt of roughly 23.4° means that the midday Sun never rises much higher than 15° above the horizon and that it sets not long after after 16:00. View from Ash churchyard, Kent.

January 17 illustrates the colder second half of the month. There had been a general fall in temperature since Jan. 9 and on Jan. 17, the temperature managed only about 7.5°C. at Heathrow. Its lowest value that same day was around -3°C.

The photographs top and were taken in the vicinity of St. Peter's and St. Paul's Church, at Ash, Kent. The view at top is a close up of ice which had formed on a puddle, and at top right, the Sun gleams through a bare hedgerow. Ice has formed in the tracks of an agricultural vehicle on the field beside the hedgerow (sunlit view below) and snowdrops are out in the churchyard. At lower left, bare branches reach for the sky in Sydenham Hill Wood, South London.

At Heathrow, minimum temperatures below 0°C occurred on Jan. 17 and 19. Jan. 22 saw temperature fall to around freezing. Meanwhile, on Jan. 19, Loch Glascarnoch (Highland) saw the UK's lowest temperature of -13.7°C, which occurred during the daytime.

Some views of wintry skies. Top left: The Belt of Venus seen after sunset on January 15, from the hill side occupied by the Rosendale Allotments, South London. This is an atmospheric effect seen just before sunrise or following sunset. The belt consists of a pinkish glow (the anti-twilight arch) produced by the atmosphere back-scatttering sunlight, which extends 10 to 20 degrees above the horizon. Beneath this, we see the darker sky which is caught in the Earth's shadow. Centre: On Jan. 17, seen from the vicinity of West Kingsdown, Kent, the light of the setting Sun passes through ice crystal clouds. Right: The Moon shines through water droplet clouds on Jan. 29, producing a so-called "corona" with a rusty-coloured ring.

Left. An empty acorn cup against a clear blue sky. The stalked cup is typical of the English or pedunculate oak (*Quercus robur*). Leaf buds are waiting to burst in the spring (Jan. 18). Common cleavers (*Galium aparine*), a common annual of disturbed ground, flourishing beside a path through the ecology area in Belair Park, South London (Jan. 18). Ice crystals on windscreen wipers of a car in South London (Jan. 29). On the final day of the month, a field near Ash, Kent was wet and nearly bare.

The Met Office reported a widespread frost on Jan. 23 and the temperature fell to -8.8°C at Upper Lambourn in Berkshire). At Heathrow, a low of -8°C being recorded. Minimum temperatures were below freezing on Jan 25, but then stayed above freezing until the last day of the month, when there was also 3 mm of rain. The top temperature recorded at Heathrow during this time was 10°C on Jan. 26.

On the closing day of the month, according to the Met Office: "*A band of rain, sleet and snow spread south early on the 31st, followed by scattered showers mainly in the east and feeling bitterly cold in a northerly wind*". Sources: UK Met Office and WeatherOnline.

SE and central S England, mean max. temp.: 8.4°C (0.9°C); mean min. temp.: 1.4°C (-0.1°C). Hours of sunshine: 70.2 (119%). Rain: 99.0 mm (124%). Anomalies re. 1981-2010 norm in brackets. Source UK Met Office.

Global climate: The 2nd warmest January on record.

The USA's National Oceanic and Atmospheric Administration reported that taken together, the world's land and ocean had a mean temperature for January 2015 of 0.77 ± 0.08°C above the 20th Century mean of 12.0° C. This made it the 2nd warmest January (2007 was warmest) since records began in 1880. Globally, land areas (1.43 ± 0.20°C above the mean))also experienced their 2nd warmest January (the warmest was 1998), whilst the oceans (0.53 ± 0.05°C above the norm) were their 3rd warmest on record (1998 was warmest).

In the Northern Hemisphere, the combined mean temperature for land and ocean was an impressive 1.02 ± 0.15°C above the norm (2nd warmest after 2007). Land areas, at 1.74 ± 0.31°C above the norm, were the 3rd warmest on record (2007 was warmest), and the Northern Hemisphere's oceans were the warmest on record at 0.59 ± 0.08°C above the mean. It certainly was not a record breaking month in the Southern Hemisphere. Here, the combined land and ocean temperature (0.59 ±20.08°C above the norm was the 7th warmest on record (1998 and 2010 were joint warmest). The Southern hemisphere's oceans (0.50 ± 0.04 above the norm) were the 5th warmest on record (warmest was 1998). It is remarkable that these figures all rate well within the top ten. Land areas for this hemisphere, however, were merely the 19th warmest in the record (0.64 ± 0.16C above the norm, with 2013 as the warmest).

Editor M. J. Heath. Editorial assistance, Penelope Stanford.

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Below: The late afternoon Sun sinks below the tree-line on January 18, 2015. A flooded willow (*Salix* spp.) coppice in Belair Park, West Dulwich, South London. The coppice, which stands adjacent to wetland-type swathes of sedges (*Carex*) and rushes (*Juncus*), is maintained in order to provide material for constructing and repairing dead hedges in the Ecology Area, managed by members of the Friends of the Park in partnership with the London Borough of Southwark.